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Ecological observations on *Rana pretiosa* in western Utah

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The ecology of the spotted frog *Rana pretiosa* was studied in a small isolated marsh in western Utah (U. S. A.) during the spring of 1992. A total of 354 egg clusters were counted, averaging 444 eggs per cluster. The majority were laid in shallow water and were attached to other clusters, forming large communal masses. Eighty spotted frogs were marked and released, comprising 28 females, 25 males and 27 juveniles. Snout-vent length and weight of the females averaged 60.5 mm and 18.5 g respectively, of the males 51.6 mm and 11.0 g, and of the juveniles 33.3 mm and 2.2 g. Females were significantly larger and heavier than males. Population density was approximately 100 frogs per hectare. The rarity and highly isolated occurrence of spotted frogs in Utah, and the general decline of ranid frog species in western North America, call for protection of this population.

INTRODUCTION

Compared to other species of ranid frogs in North America, the natural history of the spotted frog *Rana pretiosa* is still only partially documented (TURNER, 1958, 1960, MORRIS & TANNER, 1969; LICHT, 1969, 1974, 1975). The spotted frog occurs predominantly in British Columbia, Washington, Oregon, northern Idaho, and western Montana, but also sporadically in Wyoming, Nevada and Utah, where the populations tend to be small and isolated. According to STEBBINS (1985), some populations of the spotted frog in Oregon and Washington are nearly extinct because of competition with leopard frogs and bullfrogs. DUMAS (1966) previously reported that the leopard frog is competitively dominant over the spotted frog and replaces it wherever they occur together. In Utah, the spotted frog is presently known from two areas, the west desert and along the Wasatch range (STEBBINS, 1985). In 1991, the United States Fish and Wildlife Service listed the spotted frog as a candidate (category 2) under the Endangered Species Act (Federal Register 56-225:58814). Recently, BARINAGA (1990) and PHILIPS (1990) pointed out world wide declines in amphibian populations. Similar declines have been recorded in several western North American frogs (CORN & FOGLEMAN, 1984, HAYES & JENNINGS, 1986; BRADFORD, 1991). Although TURNER (1958, 1960) conducted an extensive population study of the spotted frog in Yellowstone Park, and MORRIS & TANNER (1969) reported on the reproductive biology of a population from north central Utah (Provo), not a single life

history account has been published from the extreme western populations of Utah, in particular from the Gandy Salt Marsh of Snake Valley. To date, the only evidence of spotted frogs at this site is observational. The present study was conducted to document the existence of the spotted frog in the Gandy Salt Marsh, and to assess its population structure and breeding dynamics.

Study area

The Gandy Salt Marsh is located at the southern end of Snake Valley between the ranching communities of Gandy and Trout Creek. The specific locality is at longitude 113° 55′ 13″ W and latitude 39° 28′ 48″ N. The marsh consists of several spring-fed ponds covering approximately 0 5 × 3.5 km, which drain eastward into an alkali lake bed (fig. 1). The substrate of the larger ponds is covered with a thick layer of muck, ranging in depth from about 30 cm to 1-2 m. The western edge of the marsh is flanked by an extensive mud flat, which is sparsely vegetated with salt grass (*Distichlis spicata*), grease wood (*Sarcobatus vermiculatus*), alkali rabbitbrush (*Chrysothamnus albidus*) and common reed grass (*Phragmites australus*). During spring, the mud flat is saturated and slick. The dominant vegetation surrounding the ponds (fig. 2) consists of bulrush (*Scirpus acutus*), cattails (*Typha*) and sedges (*Cyperus*) The dominant bottom vegetation consists of the stonewart alga (*Chara* sp.), common marestail (*Hippuris vulgaris*), filamentous green alga (*Spirogyra* sp.) and rush (*Juncus*). Most of the small, deep springs are covered with watercress (*Nasturtium officionale*). The study was conducted at the north end of the marsh, encompassing an area approximately 300 × 50 m with several small to medium sized ponds (Table I, fig. 1).

The virtual absence of native perennial grasses on the western boundary of the Gandy Salt Marsh, such as Indian rice (*Oryzopsis hymenoides*), galleta (*Hilaria jamesii*), needle (*Stipa comata*), and dropseed (*Sporobolus* sp.), indicates that this region has been heavily overgrazed (personal observation). This is further supported by the stunted growth and scarcity of the various native shrubs, such as greasewood (*Sarcobatus vermiculatus*), spiny horse brush (*Tetradymia spinosa*), shadscale (*Atriplex confertifolia*), snake weed (*Gutierrezia sorothrae*), big sage (*Artemesia tridentata*), indian tea (*Ephedra nevadensis*) and hop sage (*Grayia spinosa*). Most of the ground is exposed, trampled, and encrusted with alkaline deposits. The only ground cover are sporadic clumps of salt grass (*Distichlis spicata*), a halophytic species indicating high salinity. Because the western boundary slopes towards the marsh, salts are undoubtedly leaching into the ponds. Numerous cow trails lead directly into the marsh, enhancing the runoff and possibly the salinity. Although the ponds are continuously flushed by the springs, enough salts could accumulate over time to alter the freshwater invertebrate community, upon which the frogs depend for food.

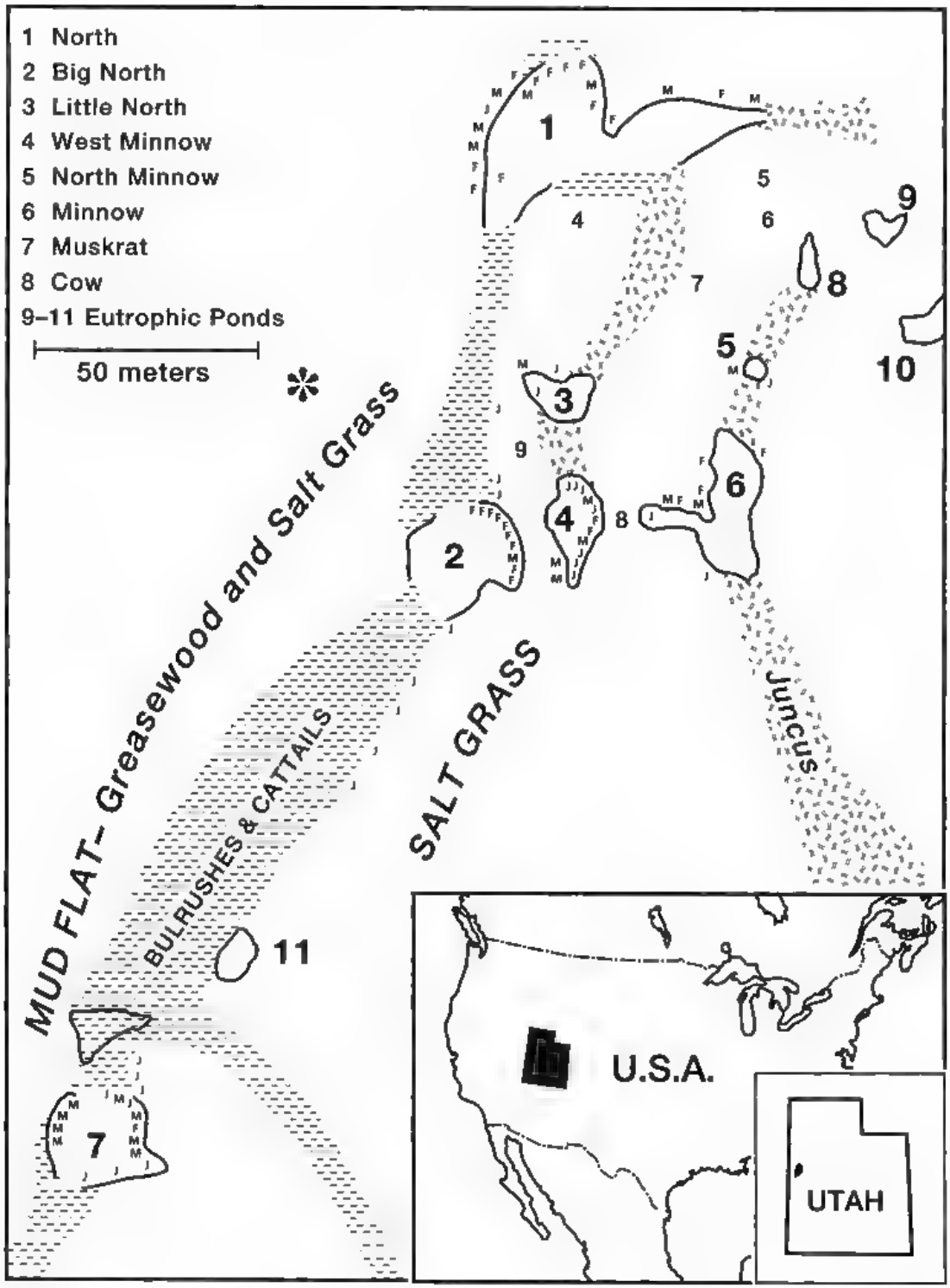

Fig. 1. – Generalized map of the study site (north end of the Gandy Salt Marsh) showing the various ponds described in the text, with inset of U.S.A. and State of Utah. The asterisk shows the location of U. S. Bureau of Land Management (BLM) Cadastral Survey, south west corner monument (1/4 S19 S30, T15S R18 W). Large numbers represent the ponds. Small numbers represent BLM metal stakes marking the location of spring heads. Letters represent the approximate site where each frog was collected. J: juvenile (yearling); F. female; M: male. Adults were collected predominantly along exposed banks.

Fig. 2. – Southwest view of Big North Pond. Photo taken during the spring of 1993. Note ice along the edges and a flag marking the location of a frog captured the previous year. Mountains in the background are in the State of Nevada.

Fig. 3. – Five recently laid egg clusters attached to each other and to the grass substrate. Note two male spotted frogs adjacent to the egg clusters. This photograph was taken during the spring of 1993.

Table I. - The number and location of *Rana pretiosa* egg clusters observed. Most clusters were attached to substrate and to each other in masses Distance and depth in meters (depth = from water surface to bottom vegetation).

Pond	Date observed	No. of clusters	Shore distance	Cluster depth	Type of substrate
South	3/16	25	0.5	0.15	*Juncus*
South	3/16	4	1.5	0.15	*Juncus*
North	3/17	60	2.0	0.15	*Chara*
North	3/17	4	1.0	0.20	*Juncus*
Muskrat	3/17	8	0.3	0.10	*Juncus*
Muskrat	3/17	9	0.3	0.10	*Juncus*
Muskrat	3/17	25	2.0	0.20	*Typha*
Muskrat	3/17	35	3.0	0.30	*Typha*
Middle	3/20	85	2.0	0.40	*Juncus*
Middle	3/20	13	0.5	0.15	*Juncus*
Fenced	3/20	5	4.0	0.35	*Juncus*
Fenced	3/20	45	5.0	0.35	*Juncus*
E. Minnow	3/21	2	0.5	0.15	*Juncus*
N. Minnow	3/21	1	0.3	0.10	*Nasturtium*
Minnow	3/21	8	0.8	0.15	*Juncus*
East	3/21	5	0.5	0.15	*Juncus*
Little North	3/23	6	0.5	surface	*Juncus*
Little North	3/23	8	0.5	surface	*Juncus*
Little North	3/23	2	0.5	surface	*Juncus*
Big North	4/3	4	3.0	0.30	*Juncus*
		354	1.4	0.20	

MATERIALS AND METHODS

Field work was conducted from March 16 to April 10, 1992. All ponds were searched at least twice a day, mornings and afternoons. Captured frogs were individually marked by clipping one or two different toes, and were then released at the site of capture after recording sex, snout-vent length (SVL), weight, specific location and temperature. The site of initial capture was marked with a road-construction flag bearing the number and sex of the frog. SVL was measured from the ventral side. Weight was recorded with a spring scale (Pesola), and frog (cloaca), water and air temperature were measured with a digital thermometer. The location and number of egg clusters observed was also recorded and marked with flags All egg clusters in the marsh were counted. The number of eggs per cluster was estimated from 22 clusters by counting the number of eggs in a small sample of each cluster, weighing the sample, weighing the total cluster, multiplying the number of eggs in the small sample by the total weight of the cluster, and dividing by the weight of the small sample. Because spotted frogs lay their egg clusters together as a mass (fig. 3),

and the clusters are intimately attached to each other, counting the exact number in the larger masses (> 45) was difficult. The southern end of the marsh system contains three large, somewhat interconnected ponds (Middle, South, Fenced), from which only eggs were enumerated (Table I).

Results

The only signs of mating activity detected during this study were sporadic choruses heard on March 16, 20, and 25. They were heard faintly from a distance, and the males stopped calling when approached to within 15-20 meters of the pond. A total of 354 egg clusters were counted during the study. Most were attached to other clusters, forming masses (fig. 3). The number of clusters in a mass averaged 17, ranging from 2 to 85 (Table I). Their average distance from shore was 1.4 m and their average depth from the surface was 0.20 m. The majority were laid over grass, to which they were firmly attached. Individual clusters were spherical, ranging in diameter from about 6 to 12 cm. The number of eggs per cluster averaged 444, ranging from 325 to 710. Most masses contained clusters in different stages of embryonic development. The average weight of clusters with embryos was significantly greater than the weight of clusters with recently laid eggs, 157 g and 113 g respectively ($t = 2.3$, $df = 20$, $P < 0.05$), but both averaged the same number of embryos, 441 and 421 respectively. Recently laid eggs were approximately 2 mm in diameter. Each egg was surrounded by two clear gelatinous capsules, the outer one about 12 mm in diameter, and the inner one about 6 mm. Tail bud embryos were about 3 mm in length. Hatching was first observed on March 25, with total length of the emerging larvae about 8-10 mm. On April 6, 36 tadpoles measured at North pond averaged 13.4 mm (range = 11-15 mm, SD 1.5). A sample of thirty-two (all 15 mm long) weighed 1.9 g, averaging 0 06 g / tadpole. By this time, most had dispersed from the masses to the grassy shoreline. Ten laboratory reared tadpoles weighed on May 19 averaged 1.98 g / tadpole (range – 1.55-3.05 g). Their bodies averaged 24.5 mm (range = 20-25) and tails 31.4 mm (range = 25-35). All had small developing rear legs.

Eighty spotted frogs were marked and released during the study, consisting of 28 females (35 %), 25 males (31 %) and 27 juveniles (34 %). The females averaged 60 5 mm snout-vent length (range = 51-70, SD = 5.7), the males 51.6 mm (range = 45-59, SD = 3.0) and the juveniles 33.3 mm (range = 26-40, SD = 3.3) (fig. 6). The females averaged 18 5 g in weight (range = 12-28, SD = 4.2), the males 11.0 g (range = 7-15.3, SD = 1.6) and the juveniles 2.2 g (range = 1.6-5.4, SD = 1.1). The females were significantly larger and heavier than the males (SVL: $t = 7.24$, $P < .001$, WT: $t = 10.3$, $P < .001$). The smallest size of a mature male was 45 mm. Mature males had distinctly dark and swollen nuptial pads on the thumbs. The dorsal coloration of both sexes was greenish brown with faint dark spots (figs. 3-4) and the under surface was yellowish, especially in the axillary and inguinal areas.

Lincoln-Peterson estimates conducted during the last five days of study averaged a total population size of 146 frogs in the north marsh. This area covers approximately 1.5 hectares, so the total population density is about 100 frogs per hectare, 1/3 each females,

Fig. 4. – An amplectant pair of spotted frogs from North Pond during early March of 1993

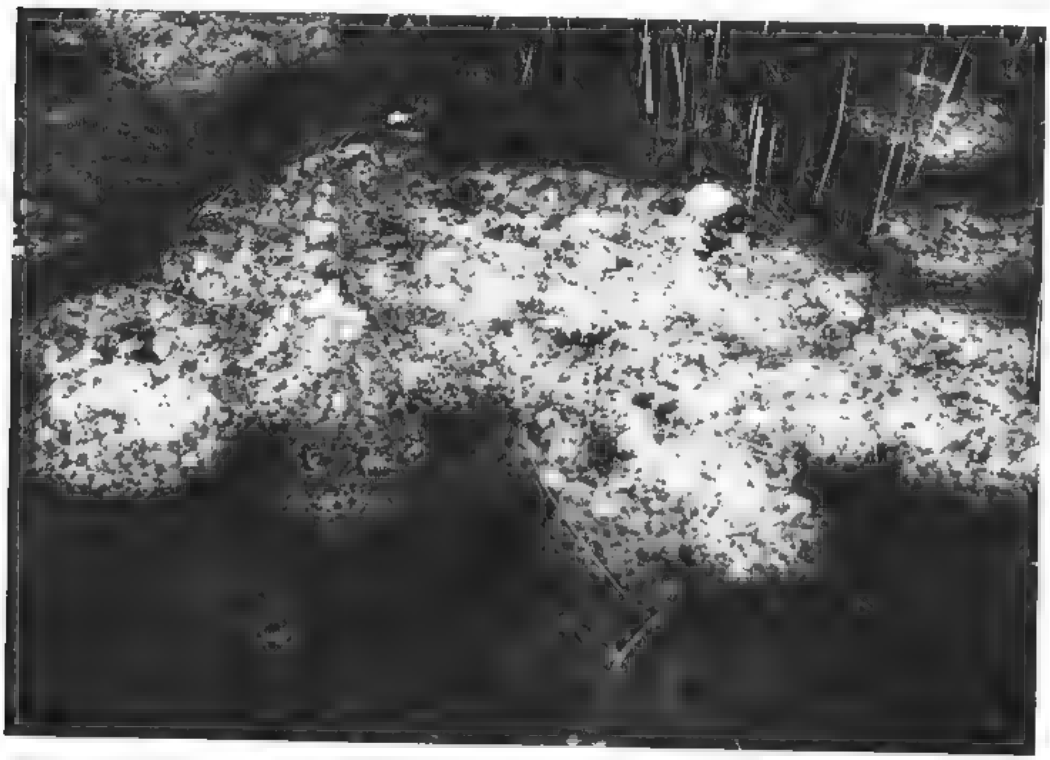

Fig. 5. – A floating mass of eggs with the surface exposed to the air. Note bulging bubbles and whitish, expanded capsules.

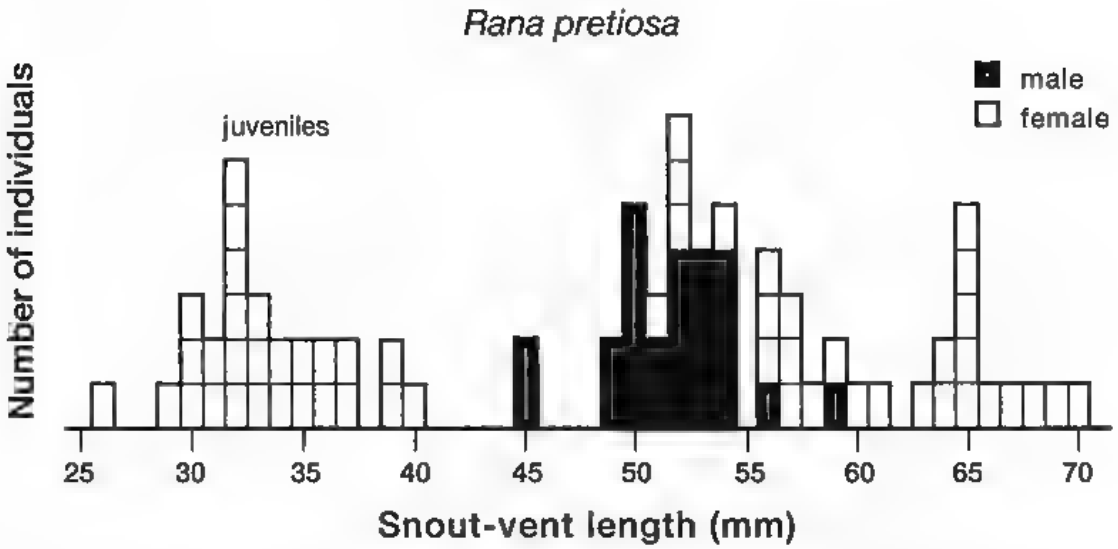

Fig 6. – Snout-vent length distribution of the juveniles and adult male and female *Rana pretiosa.*

males and juveniles. Most of the adults were captured in the large ponds, whereas most of the juveniles were captured in the small, grassy ponds and sloughs. The majority of frogs were detected on shore, partly immersed in the water and concealed under the bank vegetation. Of the 80 marked frogs, 24 (30 %) were recaptured once (Table II), 6 twice, 2 three times and 2 four times. Of the 24, 16 (67 %) were recaptured within 4 meters of their original capture site, and of these, 6 were recaptured at the same site. Two females (5 and 7) were recaptured three times at the same site. The average distance traveled away from the point of first capture by females was 25 m, by males 14 m and by juveniles 0.9 m (Table II). The longest distances traveled from the original capture site were 100 m, 150 m and 3 m, respectively. One male and one female migrated to other ponds. Mean body temperatures of adult frogs were consistently higher than both water and air, about 18.4 compared to 15.8 and 14.9, respectively.

Discussion

The virtual absence of calls after March 18-25 suggests that most of the breeding occurred during early March. Because the majority of the egg clusters were found at the beginning of the study, and some of the eggs had developed to the tail bud stage, oviposition probably occurred several days prior to the study. The most recently laid clusters were smaller (about 8 cm) than those with tail bud embryos (about 10-12 cm), suggesting that the jelly capsules expand as development progresses. Turner (1958) and Morris & Tanner (1969) report that the expansion is due to water absorption. Indeed, clusters with embryos were significantly heavier than those with eggs, even though the number of embryos and eggs was similar.

Table II. - Number of recaptures and total distance *Rana pretiosa* traveled (meters) from original point of capture. All recaptures represent different days. 0 = same place of capture.

Frog No	Sex	Locality	No. of recaptures	Distance and direction from first capture				Total distance traveled
				1	2	3	4	
1	F	Big North	4	0	25S	25S	20N	70
4	F	Minnow	1	8E				8
5	F	North	4	2S	2S	30S	2S	58
7	F	North	3	2W	2W	2W		2
10	F	Minnow	2	12W	2E			26
12	F	West Minnow	2	4S	17S			17
16	F	Big North	1	100N	Moved to N. Pond			100
17	F	Minnow	1	3N				3
18	F	North	1	2N				2
1-5	F	North	1	3W				3
1-13	F	West Minnow	1	14S				14
1	M	Minnow	1	75N	Moved to Linkage			75
8	M	Minnow	1	5				5
10	M	West Minnow	1	4W				4
11	M	West Minnow	2	3N	6N			6
13	M	Minnow	1	13E				13
15	M	Minnow	1	5				5
17	M	Minnow	1	3S				3
2-7	M	North	1	19E				19
11	J	Minnow	1	22N				22
1-18	J	Big North	1	5				5
2-6	J	Minnow	1	3S				3
2-11	J	Minnow	1	0				0
2-18	J	Little North	1	0				0

In addition to expanding in volume as development proceeds, the clusters begin rising to the surface and the inner capsules develop a population of algae, giving the clusters a greenish appearance (see SVIHLA, 1935; MORRIS & TANNER, 1969). By hatching time, the entire mass floats to the surface, where it spreads and assumes a frothy, yellowish-green texture (fig. 5). The expanding bubbles force many larvae to the surface where they die from dehydration. According to MORRIS & TANNER (1969), 10 to 20 percent of surface eggs are destroyed this way The bubbles probably develop from oxygen produced by the algae. After hatching the free-swimming larvae remain below the egg mass, attached by their mouths to the capsules, possibly feeding on the algae. The floating mass also apparently serves as camouflage for the developing larvae, and may also enhance the speed of development by increasing water temperature at the surface. The surface temperature of one mass at Little North Pond was 24°C compared to 10°C at the bottom of the pond.

The fact that the majority of egg clusters were deposited together in masses suggests a communal type of breeding in which several gravid females are attracted to the same place, perhaps by several males calling together. Similar communal breeding was reported by TURNER (1958), LICHT (1969), and MORRIS & TANNER (1969). Presumably, each egg cluster represents a single clutch, but the exact number of clutches deposited by each female has not been documented. The northern ponds contained 177 clusters (Table I), but the number of females actually captured was 28. Even the Lincoln-Peterson estimate of 51 females corresponds to less than one third of the clusters. Therefore, either the population is much larger than currently estimated, or some females lay more than one cluster.

The wide variation in number of eggs per cluster reported here, ranging from 325 to 710, suggests that some females may have split their clutches into two or more smaller clusters. Other workers have also reported wide variation in egg numbers in the spotted frog (TURNER, 1958: 206-802; LICHT, 1969. 249-935; MORRIS & TURNER, 1969: 148-1160). Some of this variation could be related to differences in the size and age of females, because female body size is positively correlated with clutch size in most frogs (PETTUS & ANGLETON, 1967; SALTHE & DUELLMAN, 1973; BERVEN, 1982). *Rana sylvatica* is known to deposit two or more egg masses in one breeding season (DAVIS & FOLKERTS, 1986). The current estimate of 51 females in the north ponds suggests that each female on average may lay 3.5 egg clusters (177/51).

Judging from the small number of frogs captured daily, only a fraction of the total population appears to be active at one time. Moreover, spotted frogs at this site are highly secretive and elusive. When approached, they usually slip into the water quietly, leaving only a small swirl. Of the 80 captured frogs, only four were observed entirely out of the water, basking on grass beneath the bank. Even so, the majority had a higher body temperature than the water, suggesting they are only partly submerged in their perches. Because most of the frogs were recaptured very close to the original site of capture, they apparently use the same perches repeatedly, suggesting they are highly sedentary. Although the overall sex ratio was nearly equal, some ponds had a predominance of one sex (Table III). The only other anuran observed in this marsh was the northern leopard frog, *Rana pipiens*. Six individuals were found at the extreme south end, one pair in amplexus. Leopard frogs are apparently rare in this marsh, or emerge much later. They also seem to prefer the larger ponds at the southern end. The northern end is inhabited exclusively by spotted frogs. However, the abundance of spotted frog eggs in the southern ponds indicates that they breed throughout the marsh system. At this time, leopard frogs at this site do not seem to be replacing the spotted frog, as has been reported previously by DUMAS (1964). During the spring of 1993, however, I observed a single adult leopard frog about 10 meters southeast of Muskrat pond.

The presence of cow dung in many of the ponds, especially the shallow ones, indicates that cattle traverse them, trampling the aquatic vegetation, and possibly the frogs themselves. Since the ponds provide the most luxuriant foliage in this region, and the only source of fresh water, cattle tend to congregate around them, grazing the succulent pasture The highest concentration of cow dung and trails is along the banks, the critical feeding, breeding and basking habitat of the frogs. Several ponds at the north end contain a dark-reddish water, seemingly from dung eutrophication. One of these ponds ("Cow

Table III. - The number of female, male and juvenile *Rana pretiosa* captured per pond.

Pond	Females	Males	Juveniles
North	12	6	1
Little North	0	1	2
Big North	9	1	2
West Minnow	2	4	7
North Minnow	0	1	1
Minnow	4	2	2
Muskrat	1	8	8
Linkage	0	0	6

Pond") is littered with bones from a dead cow, which apparently died within it. All such ponds are devoid of aquatic vegetation, invertebrates and frogs. The remains of a single dead cow in a fertile pond would undoubtedly destroy its entire frog population. A major ranching problem in this region (Snake Valley) is the frequent drowning of cattle in the deeper ponds, which are usually fenced to prevent miring (Terry HALE, pers. comm.).

Data from this study suggest that the population of spotted frogs at the Gandy Salt Marsh is small, perhaps comprising less than three hundred individuals. The marsh itself also is very small, consisting of a few isolated springs within a vast arid valley. According to BEGON et al. (1990), when local populations are reduced to "several hundred" individuals, they are prone to becoming extinct because of localized catastrophes, such as drought. They also list the major causes of rarity according to the International Union for the Conservation of Nature and Natural Resources. Most of these causes of rarity and extinction apply to the ecology and distribution of the spotted frog in western Utah. Its habitat is rare (isolated fresh water springs). Its resources are limited (confined to a few spring-fed ponds). It cannot disperse to other similar habitats, and it is limited by cattle, which degrade its aquatic habitat and trample its breeding and basking sites In the interest of protecting this vulnerable endemic species, livestock grazing should be discontinued from the western boundary of the marsh, the principal watershed. This would allow repopulation of the native grasses and shrubs, reducing erosion, evaporation, and salinization.

RESUMEN

La ecología de la rana pinta *Rana pretiosa* fue estudiada en varios lagitos aislados en la parte norteña de la cienega salada de Gandy en la frontera occidental de Utah durante la primavera de 1992 Un total de 354 nidadas fueron contadas con un promedio de 444 huevos por nidada. La mayoría fueron puestas a orillas de lago pegadas con otras, formando masas comunales. Un total de 80 ranas fueron marcadas y soltadas consistiendo de 28 hembras, 25 machos y, 27 añeras. El promedio del tamaño (hocico-cloacal) y peso

de hembras fueron 60.5 mm y 18.5 g, respectivamente de machos 51.6 mm y 11.0 g, y de añeras 33.3 mm y 2.2 g. Hembras son significativamente más grandes y más pesadas que machos. Densidad poblacional es aproximadamente 100 ranas por hectarea. Debido a la rareza y distribución muy aislada de esta rana en Norte América debería protejerse la población en Gandy de su posible extinción.

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